Enhancing Operational Drought Monitoring and Prediction

Eric F Wood
(Princeton University)

CTB Science Advisory Board (SAB) Meeting
November 16, 2012
NOAA Center for Weather and Climate Prediction (NCWCP)
College Park, MD

PRINCETON UNIVERSITY

Success in R→O: the NLDAS experience

Initial partners: NCEP/EMC (Mitchell), NWS/OH (Schaake) NASA/GSFC (Houser), Princeton (Wood), U Washington (Lettenmaier), Rutgers (Robock)

Timeline:

~2000 – 2006: (Research phase)

- Develop/improve NCEP Land surface model, Noah, based on state-of-the-art modeling. Noah made its way into GFS and CFSv2;
- Long-term (1948-~2000) forcing data set over CONUS that provided 'hindcast' forcings (U Washington);
- Development of the approach for objective drought monitoring based on LSM and SM percentile index (Princeton);

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 109, D07S90, doi:10.1029/2003JD003823, 2004

The multi-institution North American Land Data Assimilation System (NLDAS): Utilizing multiple GCIP products and partners in a continental distributed hydrological modeling system

Kenneth E. Mitchell,[1] Dag Lohmann,[1] Paul R. Houser,[2] Eric F. Wood,[3] John C. Schaake,[4]

A Long-Term Hydrologically Based Dataset of Land Surface Fluxes and States for the Conterminous United States*

E. P. MAURER, A. W. WOOD, J. C. ADAM, AND D. P. LETTENMAIER

Department of Civil and Environmental Engineering, University of Washington, Seattle, Washington

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 109, D24108, doi:10.1029/2004JD005182, 2004

A simulated soil moisture based drought analysis for the United States

Justin Sheffield,[1] Gopi Goteti,[2] Fenghua Wen,[3] and Eric F. Wood[1]

Received 30 June 2004; revised 7 October 2004; accepted 25 October 2004; published 29 December 2004.

[1] Droughts have severe economic, environmental and social impacts. Timely determination of the current level of drought may aid the decision making process in reducing the impacts from drought. In this study, high-resolution, land surface hydrology simulations using the Variable Infiltration Capacity (VIC) model are used to derive a hydrologically based drought index. Soil moisture data from a retrospective simulation from 1950 to 1999 over the continental United States are used to develop probability distributions of monthly average soil moisture, and the relative position of

Success in R→O: the NLDAS experience

Initial partners: NCEP/EMC (Mitchell), NWS/OH (Schaake) NASA/GSFC (Houser), Princeton (Wood), U Washington (Lettenmaier), Rutgers (Robock)

Timeline:

~2006-2010: (Operational capability phase)

- Develop experimental seasonal hydrological forecasting system based on CFSv1, CPC seasonal outlooks and ESP-method (UW and PU)
- Transfer NLDAS multi-LSM objective drought monitoring and seasonal hydrological forecasting system to EMC (Princeton)

~2010-2012 phase (operational stalled phase)

- Drought monitoring to become operational by NCO – ongoing?
- Seasonal hydrological forecasting system at EMC gets "broken" Feb 2012
- Implementation of CFSv2 into the seasonal hydrological (drought) forecast system, upgraded at Princeton, on-going at EMC.

Research partners “Operational Testbed” at Princeton (Drought Monitoring)

Drought Monitoring and Hydrologic Forecasting with VIC

Nowcast/Forecast | Historical Droughts/Hindcast | Documentation | About the Project

As of 2012/05/01, CFS forecasts are switched to CFSv2. Hover mouse on items to see more info.

Product/Date/Variable (change on click)

Monitoring validated < 2012/11/08 > for (•) Soil Moisture ( ) Snow ( ) Streamflow ( ) Precipitation

Forecast initialized < 2012/11/01 > for ( ) Soil Moisture ( ) Drought Probability

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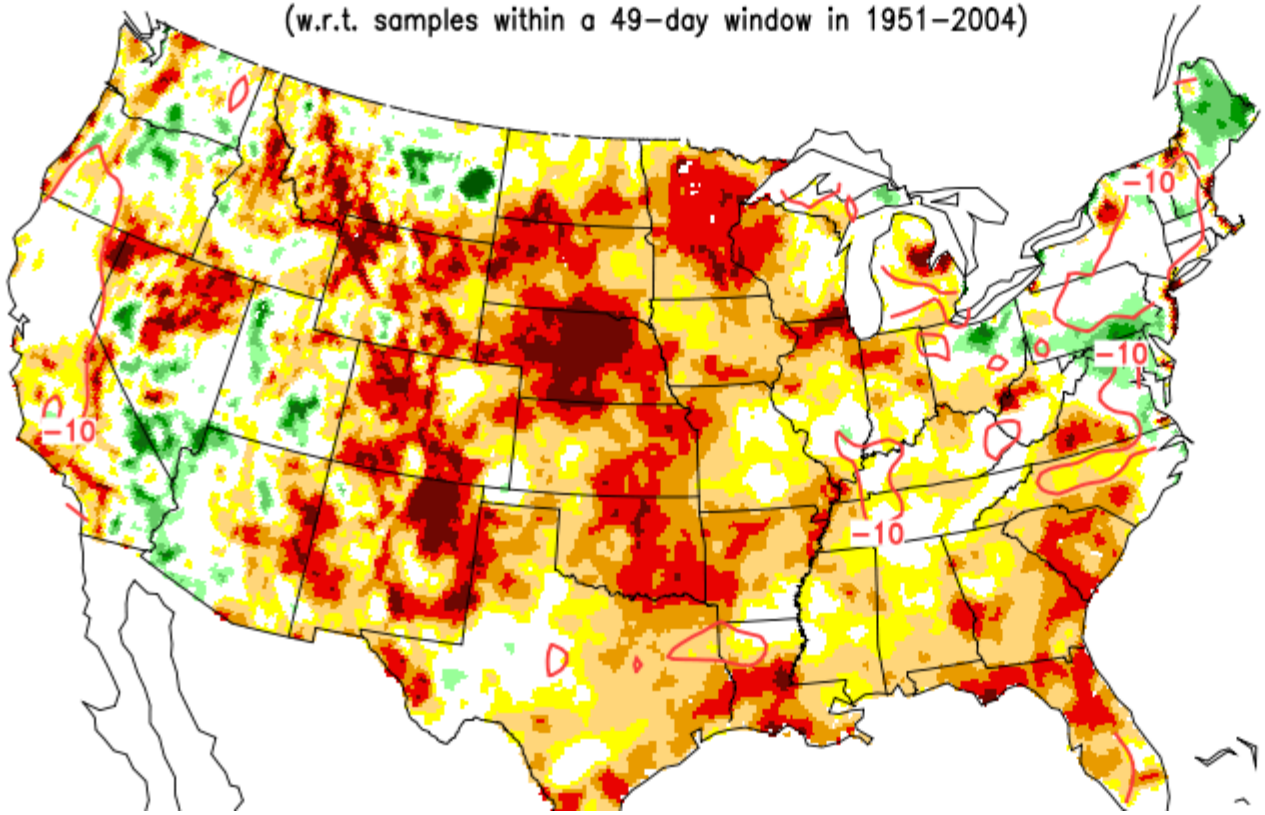
Total Column Soil Moisture Percentiles for 2012/11/08
based on VIC Simulations forced with NLDAS-2
(w.r.t. samples within a 49-day window in 1951-2004)



Timeline (change on hover)

Preceding Monitoring
2012/09/06
2012/09/13
2012/09/20
2012/09/27
2012/10/04
2012/10/11
2012/10/18
2012/10/25

Forcast	CFS	CPC	ESP
2012/11	0.5mo	0.5mo	0.5mo
2012/12	1.5mo	1.5mo	1.5mo
2013/01	2.5mo	2.5mo	2.5mo
2013/02	3.5mo	3.5mo	3.5mo
2013/03	4.5mo	4.5mo	4.5mo
2013/04	5.5mo	5.5mo	5.5mo

Monitoring from other centers:
- US Drought Monitor
- USGS Streamflow/Drought
- CPC Drought Severity
- CPC Soil Moisture
- UW Surface Water Monitor
- NLDAS Drought Monitor

“Operational Capability Testbed” at NCEP

NLDAS | Forcing Data | Model Output | NLDAS Monitor | NLDAS Forecast | Quick Links

NLDAS Drought Monitor

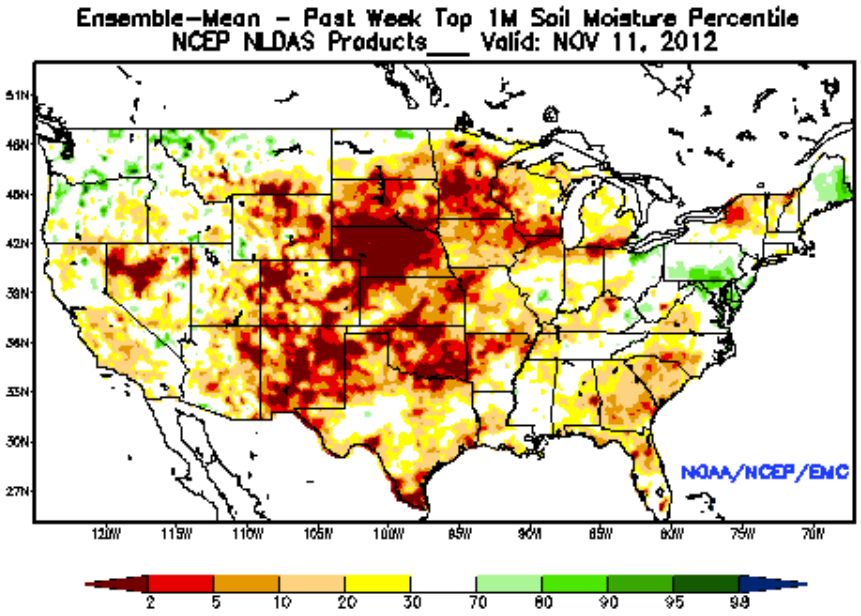
Soil Moisture

NOTE: This page is best viewed with a screen resolution of at least 1024x768

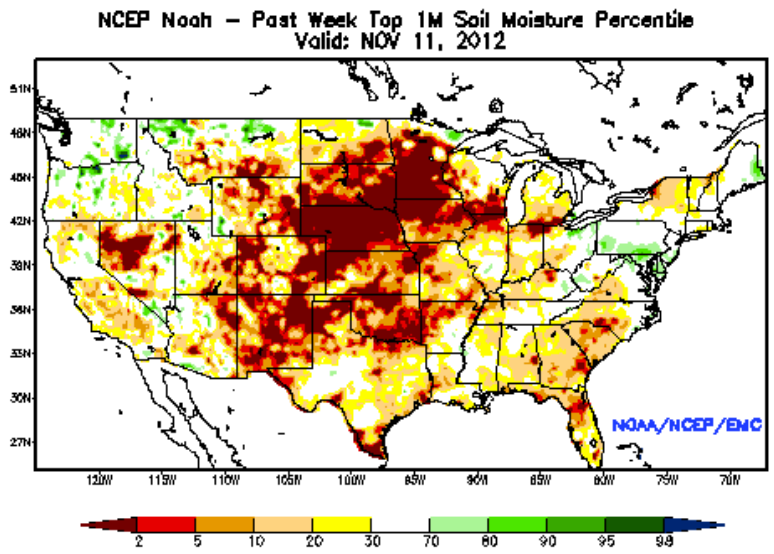
DISCLAIMER: Any data provided on this server should be used for research or educational purposes only. This data should NOT be relied on for any operational use as data gaps can occur due to hardware failure and/or model upgrading procedures.

Ensemble Mean LSM OUTPUT:

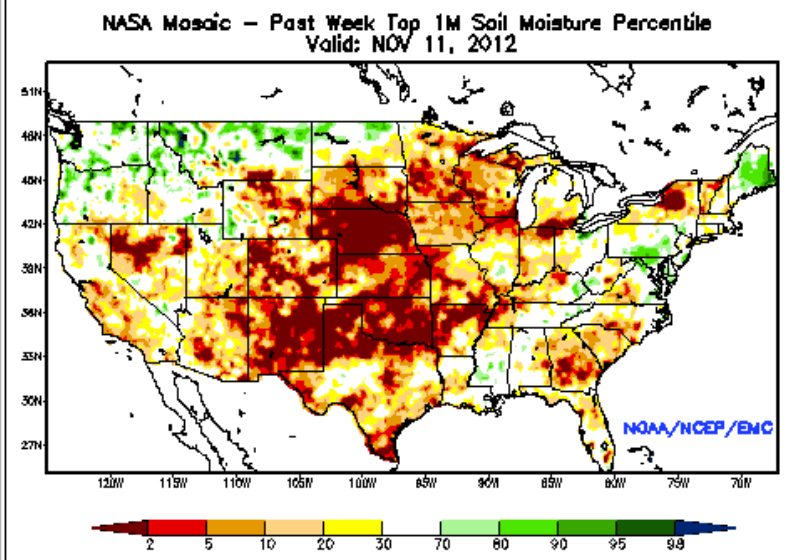
Past Week Top 1M Soil Moisture Percentile



NOAH LSM OUTPUT:

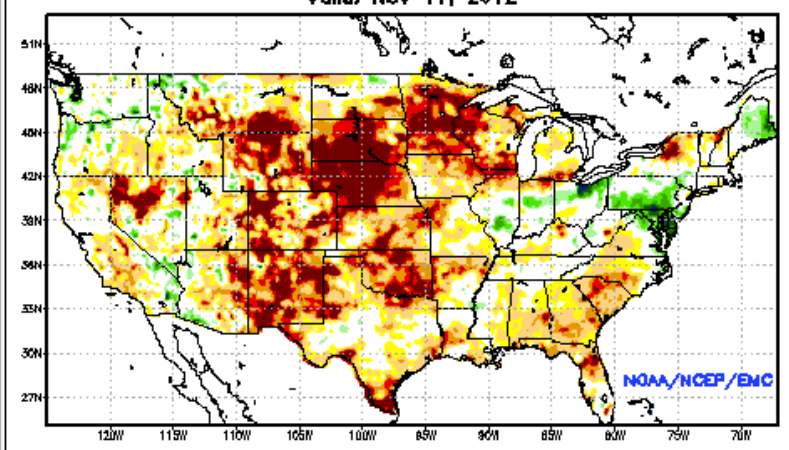


MOSAIC LSM OUTPUT:

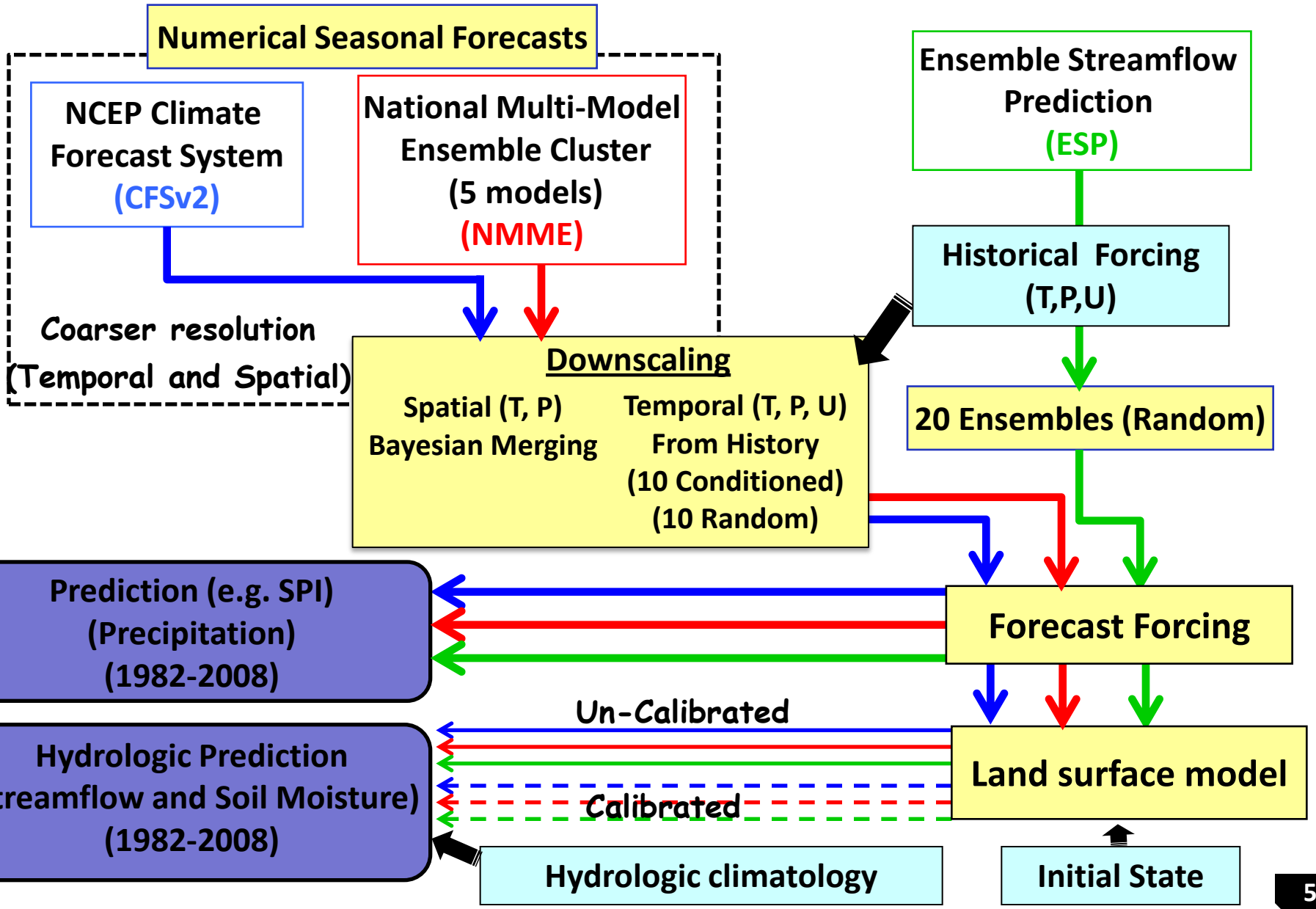


SAC LSM OUTPUT:

VIC LSM OUTPUT:



Hydrologic Forecast Methodology



Research partners “Operational Testbed” at Princeton (Drought Forecasting)

Drought Monitoring and Hydrologic Forecasting with VIC

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Monitoring validated < 2012/11/08 > for ○ Soil Moisture ○ Snow ○ Streamflow ○ Precipitation

Forecast initialized < 2012/10/01 > for ◉ Soil Moisture ○ Drought Probability

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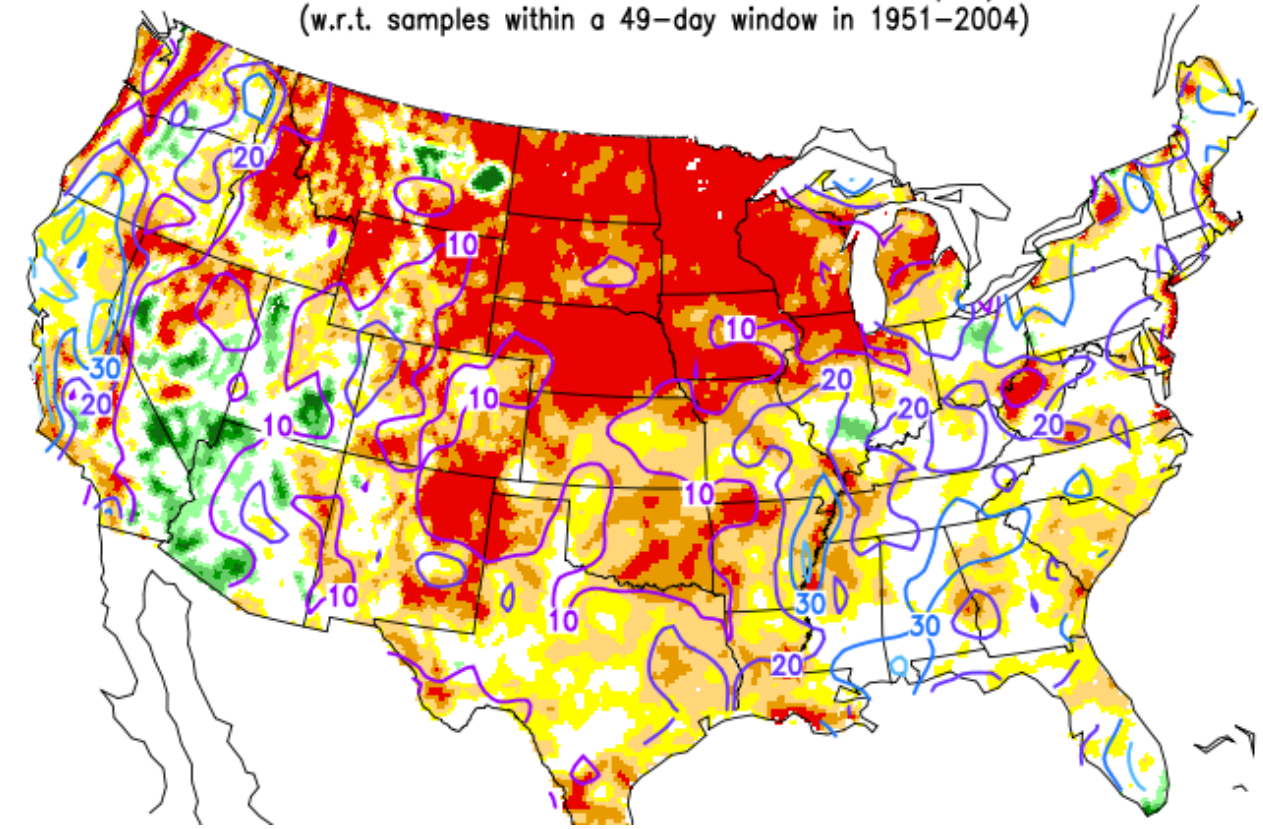
Total Column Soil Moisture Percentiles (Ensemble Median) for 2012/10
based on CFSv2–VIC Forecasts initilized on 2012/10/01
(w.r.t. samples within a 49–day window in 1951–2004)



Timeline (change on hover)

Preceding Monitoring
2012/08/09
2012/08/16
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2012/08/30
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2012/09/13
2012/09/20
2012/09/27

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2012/12	2.5mo	2.5mo	2.5mo	
2013/01	3.5mo	3.5mo	3.5mo	
2013/02	4.5mo	4.5mo	4.5mo	
2013/03	5.5mo	5.5mo	5.5mo	

Monitoring from other centers:

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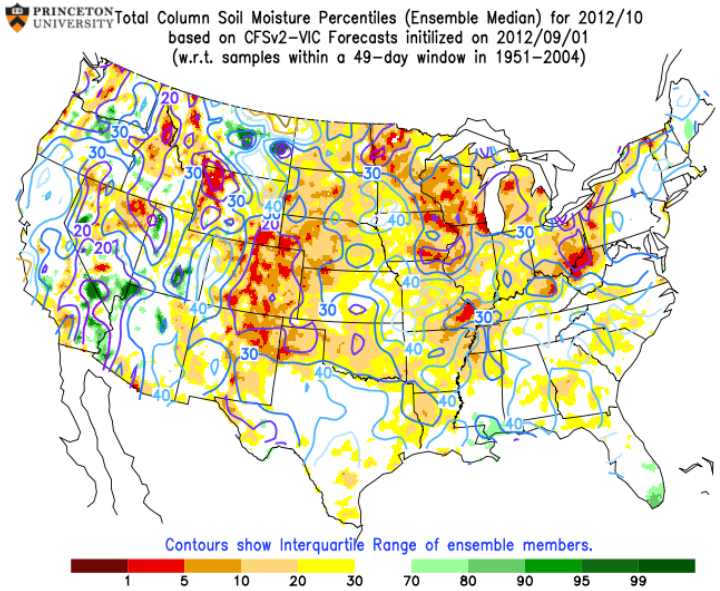
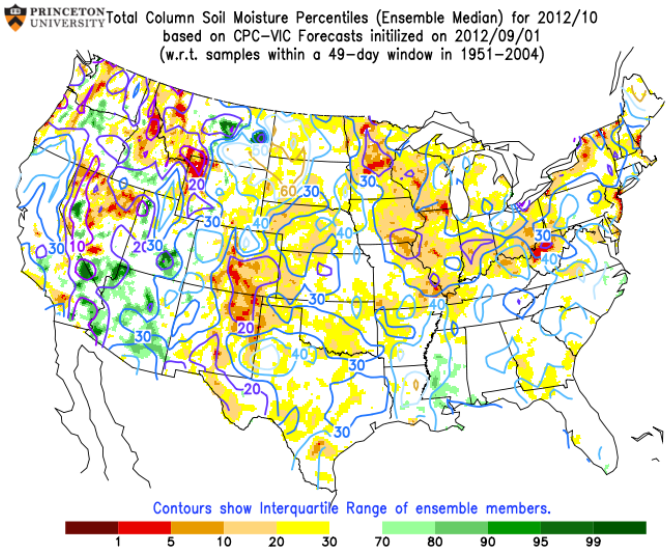
The seasonal hydrological Forecasting Problem

October forecast, initialized 9/1/2012

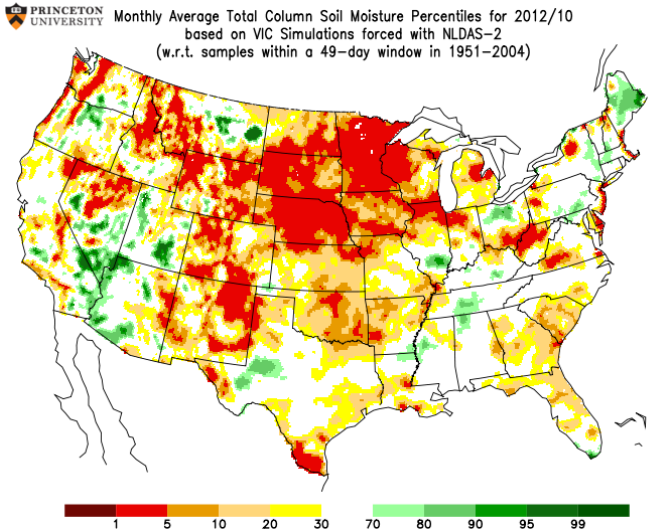
CFSv2-based forecast



CPC 'official outlook' forecast



October forecast verification

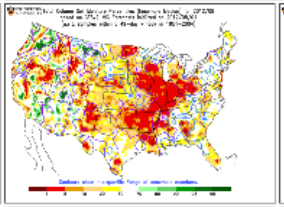
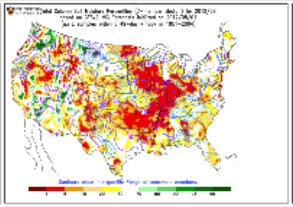
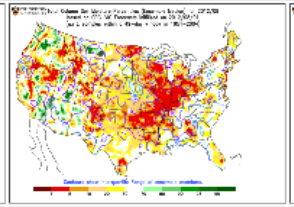
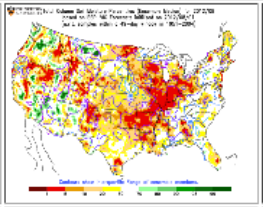
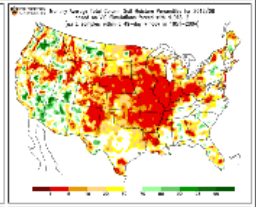
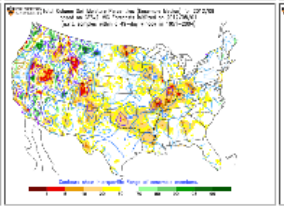
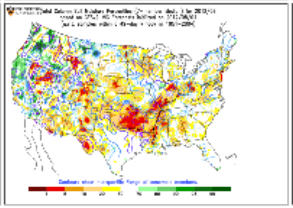
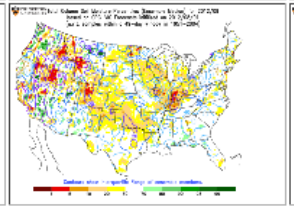
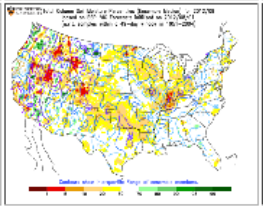
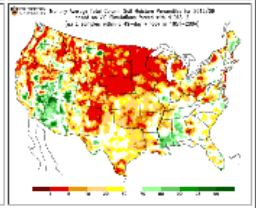
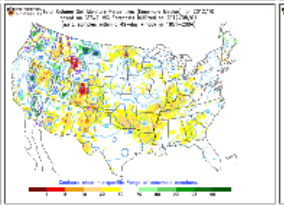
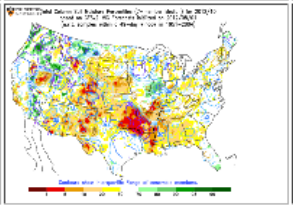
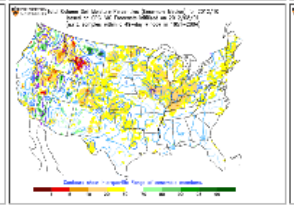
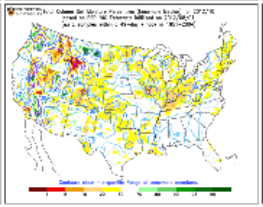
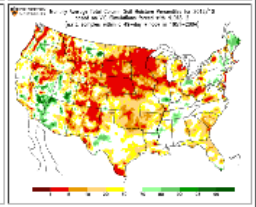
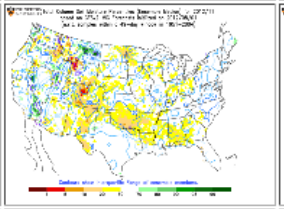
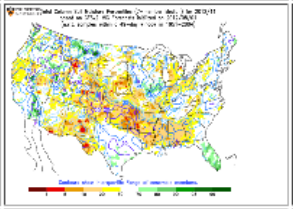
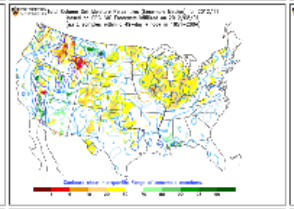
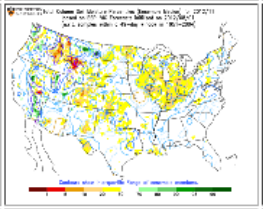
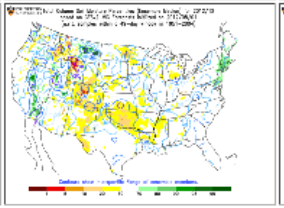
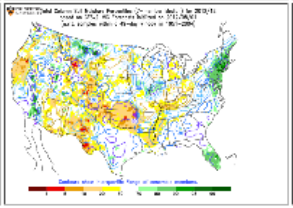
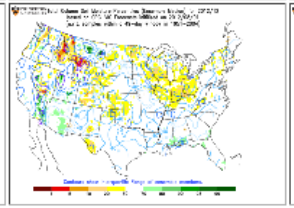
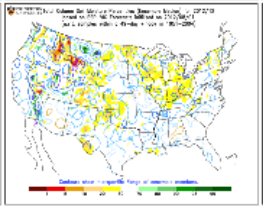


Drought Monitoring and Hydrologic Forecasting with VIC

Drought Forecast Verifications

As of 201205, all the CFS forecasts have been switched to CFSv2.

Available period: 200806 200807 200808 200809 200810 200811 200902 200903 200904 200905 200906 200907 201005 201006 201007 201008 201009 201010 201011 201012 201101 201102 201103 201104 201105 201106 201107 201108 201109 201110 201111 201112 201201 201202 201203 201204 201205 201206 201207 **201208** 201209 201210

Target Month	CFS-based Forecast (full) released on 201208	CFS-based Forecast (most likely) released on 201208	CPC Outlook-based Forecast released on 201208	ESP Forecast released on 201208	Nowcast (monthly mean)
Initial condition					
201208					
201209					
201210					
201211					
201212					

NLDAS Drought Forecast Analysis

The system developed by Princeton Univesity and University of Washington was transitioned to NCEP/EMC in July 2008, and now it is run as the EMC experimental forecast system.

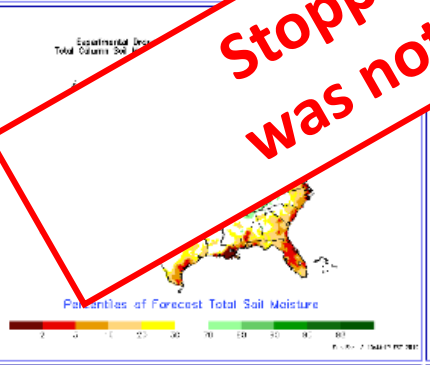
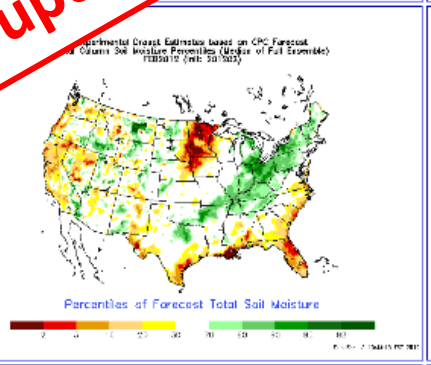
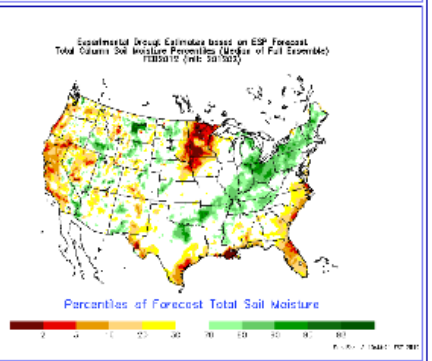
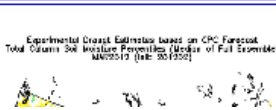
Drought Forecast using 201202 Initial Condition

How to read forecast maps

Forecast Maps

- These forecasts are produced monthly at the beginning of each month using the initial condition that i… he first day of the month.
- The CFS-base forecast uses all CFS seasonal forecast initialized during the previous month. For example, to make seasonal… rting from 20080801, we use CFS forecast initialized during 20080701 to 20080731 (62 members) to form the forecast distribution bef… erging method.
- The CPC outlook-based forecast uses the CPC output releases during the previous month as the forecast distrib… xample, to make seasonal drought forecast starting from 20080801, we use CPC outlook…
- Each column is the 6-month soil moisture forecast from one forecast approach, and each row… ch individual month, showing monthly average.
- Since we are doing ensemble f…
- The first column is CFS-based forecast using 20 ensemble members to calculate the medi… outlook-based forecast using 20 members, and the third column is Ensemble Streamf… mbers.
- NLDAS drought forecast inclu… d forecast probability analysis.
- More system descriptions and t… on Seasonal Hydrological Forecast System.

Stopped running, 2/2012 was not updated to CFSv2

Target Month	CFS-based Fore…	…-Based Forecast	ESP-based Forecast
201202			
			

Data and computational challenges for drought monitoring and forecasting R→O

1. Data.
   It should be noted that CFSR is unavailable after 2009; that only a reduced resolution of CFSv2 reforecasts are available at NCDC; and there is no archive available to the research community of CFSv2 forecasts after the 7-day posting of real-time forecasts at NCEP. So how can research into the 2011 and 2012 droughts be carried out? Or developing improved drought forecasts in general?
2. Computational challenges for hydrologic seasonal forecasts.
   Monitoring, currently operationalized at EMC, 4 LSM with deterministic initial conditions and forcings.
   Forecasting, currently at Princeton, 3 forecast models, 20 ensembles, 9 months, 1 LSM, deterministic initial land conditions = 45 simulation years/forecast start date. Under NLDAS with 4 LSM, 180 years/ forecast. Under NMME (6 models) +CPC official outlook+ESP, 4 LSM = 480 years/forecast (still with deterministic initial conditions.)

Summary and lessons learned of NLDAS drought R→O experience

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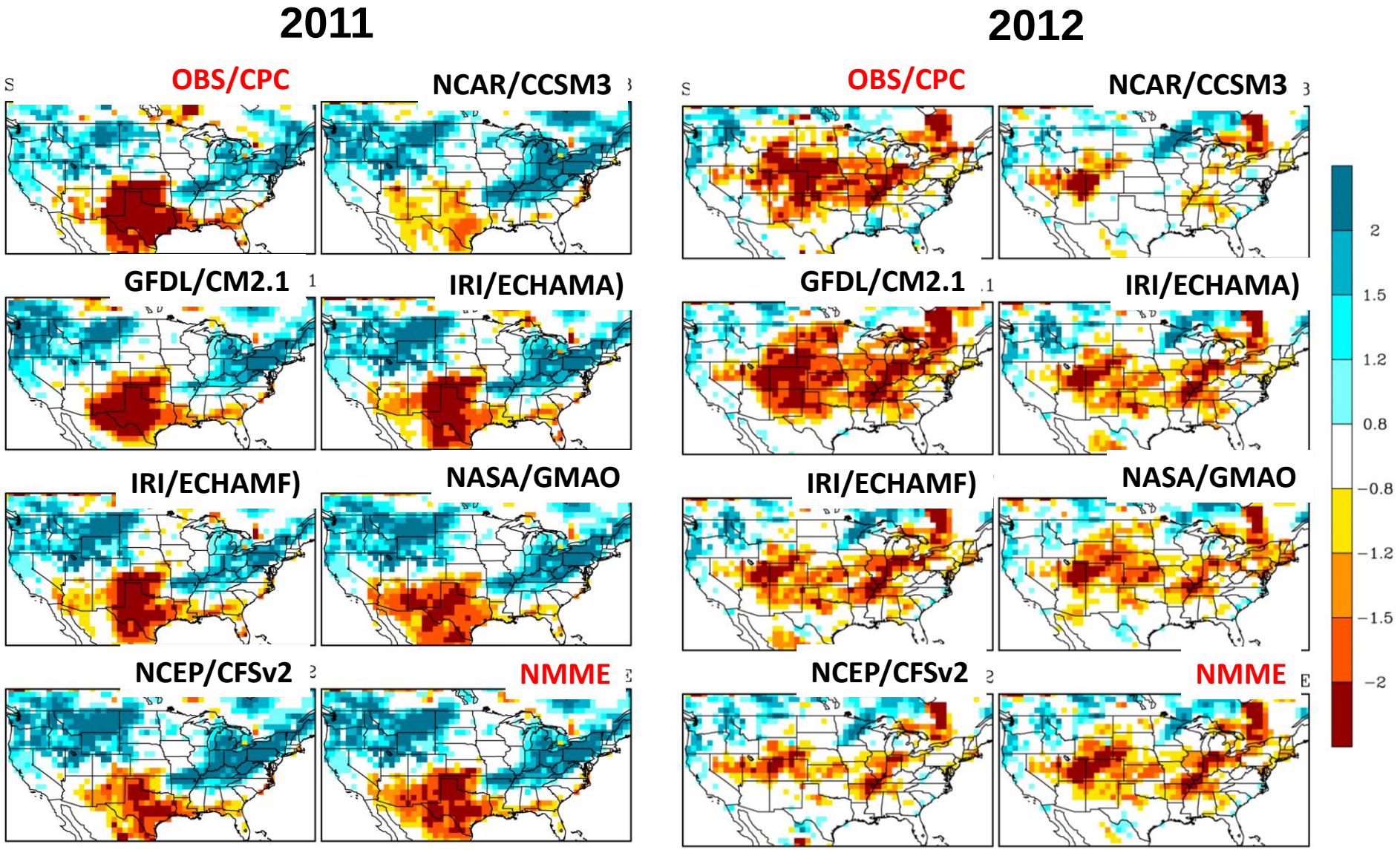
From 2010-2012 the R→O efforts weakened due to CPO moving away from “core” funding towards smaller R-based funding. Also within-NCEP transition from “operational capability” (experimental operations) to “operations” lagged due to CPC-EMC-NCO challenges?

2012 – forward. To what extent will NCEP operational products benefit from CPO investments in research (e.g. NMME) if there isn’t a clear path to support transition to operations (i.e. stable funding to the CTB?)

Computational challenges for drought monitoring and forecasting

SPI6 for MAMJJA, 2011 & 2012

SPI6: Prior 3-month (MAM) observation with the current (JJA) 3-month forecast



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An additional hidden issue never discussed within NCEP/CTB/CPO is the operational developments in OH and the RFOs. They are implementing at RFCs seasonal hydrological forecasting based on CFSv2. Where's the discussion?.